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Time-series within automatically generated ROIs from wildlife cameras are well able to explain variability in forest phenology on a temperature gradient

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Using RGB camera data (e.g. webcams, wildlife cameras) has great potential to measure forest phenology over climate gradients, because of its very high temporal resolution, while at the same time being more objective and less time consuming than in situ observations. To make images useful for the purpose of measuring phenological events, such as Start of Season (SOS) and End of Season (EOS), there is need to derive Regions of Interest (ROI) objectively and (semi-)automatically. In order to answer this need, Bothmann et al. (2017) proposed a method which randomly sets a number of pinpricks in the image and calculates how greenness over time from all other pixels correlates to these different pinpricks. Subsequently, ROIs are created by discarding the pixels with low correlation, using multiple thresholds. Despite its advantage of being automated and more objective compared to prevailing expert-based ROIs, and therefore its potential applicability for phenological research using a large amount of cameras, the method has not been reproduced for this purpose so far. Therefore, we assess here how well this method is able to separate foliage of different deciduous species from evergreens and phenologically irrelevant components in time-lapse wildlife camera data and in that way how suitable it is in explaining variation in phenology over a temperature gradient. We used 73 Cuddleback wildlife cameras troughout Bavaria which were installed within nine quadrants of 6*6 kilometers spanning a temperature gradient of 2.5°C. Hourly taken images of deciduous forests in spring, summer and autumn 2019 were analysed. Half of them were facing canopy, and half of them were facing understory. We applied the principles of the method from Bothmann et al. (2017) and assigned the best matching ROI to foliage of *Fagus sylvatica* or other deciduous species. Within this ROI, mean Green Chromatic Coordinate (GCC), a greenness index, over all pixels within the ROI, was derived per time-stamp. Afterwards, a time-series was calculated on these GCC values and with a suitable combination of curve-fitting techniques, SOS and EOS were derived, expressed in Day of Year (DOY). We compared these SOS and EOS dates with weekly in situ observations of spring and autumn phenology, which were taken in the same quadrants. Despite that Bothmann's method was developed on a single tower-mounted scientific webcam which viewed on canopy from above, while we made use of wildlife cameras at 73 different locations facing either understory perpendicular or canopy from below, it was able to distinguish *F. sylvatica* and other deciduous foliage from phenologically less relevant information. Time-series derived from these ROIs were able to explain variability in

phenology between understory and canopy and over the temperature gradient similarly and supplementary to in situ observations.